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E7.2 · 10.358
CR - 129691

Contract NAS 5-21810

Bi-Monthly Progress Report

(E72-10358) UTILIZATION OF ERTS-1 DATA TO MONITOR AND CLASSIFY EUTROPHICATION OF INLAND LAKES Bimonthly Progress Report, 1 Oct. - 1 Dec. P.E. Chase (Bendix Corp.) 1 Dec. 1972 7 p CSCL 08H G3/13 00358

N73-14346

Unclas

Reporting Period

1 October to 1 December 1972

Prepared By: Bendix Aerospace Systems Division

Prepared For: NASA/Goddard Space Flight Center

SECOND TYPE 1 PROGRESS REPORT
(Period: 1 October to 1 December 1972)

a. TITLE: Utilization of ERTS-1 Data to Monitor and Classify Eutrophication of Inland Lakes. GSFC PR 518, MMC 598, Phillip E. Chase

b. Objectives:

The objectives of the study are to demonstrate the feasibility of ERTS in measuring the state of eutrophication of inland lakes as a broad survey monitor. Specific objectives are:

1. Determine the minimum size of inland lakes detected by ERTS when considering factors of color, size, shape, and shore definition.

2. Determine correlation of surface color to various indices of eutrophication for preparing charts of eutrophication versus surface color. Such indices are algal count, Secchi Disk transparency, leptopel content, macrophyte extent, phosphates, etc.

3. Determine if algal blooms are detectable by ERTS when they occur and color the surface of small inland lakes. Algal blooms are an indicator of enrichment.

4. Determine if changes in leptopel level are detectable by ERTS. This is another measure of eutrophication that can be related to ERTS.

5. Determine the feasibility of establishing classification of levels of inland lake eutrophication by either lake, pond, and swamp taxonomies or by individual indicators such as surface color, transparency, leptopel level, and appearance of algal blooms.

c. The ERTS-1 data is arriving in "bits and pieces". The imagery received for the Oakland County, Michigan test site are scenes 1032-15521 and 1032-15523. The order included 9.5 inch positive black and white transparencies in bands 4, 5, 6, 7 for both scenes. Required are the 70mm negatives and the CCT. Lack of prompt shipment of data, the standard catalog, and 16mm strips is still a problem.

d. Accomplishments

(1) Status of preparation tasks to date:

1. Equipment set-up for biological, chemical, and spectral analysis of lake samples 50% complete. Spectral analysis of water samples and final selection of sampling rates depend upon range of color discernable in ERTS-1 imagery and on CCT.

2. Photographic set-up for optimum enlargement and color composite production is 80% complete.

3. Computer software for display and analysis of CCT's is at least 80% complete.

4. Literature search is 75% complete.

(2) Visual and densitometric analysis of initial scenes received.

Scenes 1032-15521 and 1032-15523 have been examined visually (aided and unaided) and with a diffused transmission densitometer (MacBeth TD 102) for cursory comparisons of each channel density across a lake and between lakes, differences between channel densities for the same lakes, and differences between scenes for the same lakes in the same channels.

It was found that the density changes from lake to lake and across a lake in one channel. Densities are different from channel to channel for the same lakes. Densities do not vary from scene to scene for the same lakes that appear in the region of overlap.

The minimum size lake detectable in the imagery in channels 6 and 7 has an elliptical shape of 500 ft. by 650 ft. Other lakes just slightly larger are observable. These visual observations were made with a 10X glass and a 9.5 inch Black and White positive transparency.

These results are encouraging because the weather conditions were 70% overcast with some apparent haze. It is necessary to determine that a variation in density exists among different lakes, across a lake and between channels for the same lake. The consistancy in density values between scenes in an overlap area tends to remove scene to scene variation as a potential source of error. The detection of lakes as small as 500ft. by 650 ft. (approximately 7 acres and 5 picture elements) means that 40 acre lakes (smallest test lake) with approximately 29 picture elements will be observed clearly. It is likely that algal blooms or other distinctive water quality features extending over approximately 25% of the total lake surface will be detected. The observed differences in the ERTS-1 imagery existed on a 70% cloud cover hazy day far less favorable for obtaining spectral density differences than the levels of a CCT would be a clear day.

(3) Activities planned for the next reporting period.

1. Conduct a detailed analysis of scenes 1032-15521 and 1032-15523 for different lakes observed in Oakland County either not obscured

by clouds or in cloud shadows. The intention is to answer minimal size detected as a function of shape and surroundings, primarily.

2. Conduct a densitometric analysis of Orchard Lake and Lake Angelus in the four channels. (Channels 4 and 5 appear to contain features which might be only bottom reflection from shallow areas. Apple Island is easily observed in the imagery). Compare to bathymetry charts for shallow areas and to ground observation and data available for that day.

3. Prepare a maximum positive enlargement of Orchard Lake and Lake Angelus to determine the smallest feature observable. Compare to densitometry, bathymetry and ground truth data.

4. Upon receipt of the CCT's for scene 1032-15521 (or 1032-15523) display Orchard and Angelus Lakes (and other lakes) on the CRT color display to judge the features available under maximum electro-optical enlargement. Record display photographically and compare to densitometry, bathymetry, photographic enlargement and ground truth. All four channels will be examined for Orchard and Angelus Lakes.

5. Prepare a Type II report of the results of the four previous tasks. The results are expected to be significant.

6. Complete the literature search, the photographic enlargement procedure, computer software development (currently underway and nearing completion) for statistical combination of 4 ERTS-1 bands.

7. Work will continue on correlation of the various methods of obtaining spectral characteristics of water samples, on ground level color observation, Bendix test site radiometer, aircraft MSS channels and ERTS-1 MSS channels. Spectral characteristics of typical lake contaminants that affect water color will be obtained if available.

8. Develop a theoretical model tracing the sun light from the top of the atmosphere to the water surface (reflected or refracted); represent the amount of back scatter from refracted light as it descends into the lake where it is reflected or refracted back to the water/air interface and up to the satellite. Even though absolute radiometric calculations are not possible, relative calculations are possible that might explain why certain channels do not record certain contaminants. The intention of the overall study is to correlate lake water color as received in four channels to the degree of eutrophication in lakes. This task will attempt to relate physical understanding to the statistical correlation.

e. Although the ERTS-1 imagery arrived only one week previous to the end of the reporting period, a cursory analysis indicates several applications of ERTS-1 imagery.

1. Channel 7 is highly useful in surveying surface water in lakes, rivers and large marshes. It is likely to miss detection of elliptically shaped bodies of 4 acres or less. Further, it is possible that the bodies are distorted and displaced because of lack of correction for sensor response (rise) time. These errors might not be critical because (1) location accuracy is not essential to a surface water survey and (2) an obviously distorted image is often not in error in excess of 5%. See attached table for partial listing of lakes observed in imagery.

2. The finding that Orchard Lake and other lakes in Oakland County have different densities in channels 4, 5, 6, 7 is important because it implies that the lake wide water color average is different in the separate channels. Channels 6 and 7 were constant in tonal quality among all the lakes while channels 4 and 5 varied from lake to lake and in various parts of Orchard Lake. These findings are significant because it means that small inland lake color differences are recorded by the MSS even on a cloudy or hazy day. Any satellite monitoring system which is based upon correlations of water color to trophic state, may sense color differences even under poor conditions. It also confirms that ERTS-1 is performing well enough to be used for correlation to ground truth and aircraft underflights.

f. No release of information or requests for permission to release information have been made during the reporting period.

g. No changes in operation procedure required.

h. A standing order change dated 12 October 1972 requested acceptable cloud cover be 60% instead of 40%.

i. None have been submitted. They will be submitted for the scenes received to date in the near future.

j. Retrospective orders were submitted dated 12 and 25 October, 3 November, and 8 December of 1972. A change in the retrospective order was made 21 November 1972. The request to add the following types of data was made:

Copy	MSS	CLD	Qual	Typ	FMT
2	M	6			T
2	M	6			N
2	7	6		B	P
2	M	6			P

k. Work to date conforms to schedule (Item c in paragraph 3. 1 of Spec 5-250-P-1C).

SAMPLE OF LAKES VISIBLE IN ERTS 1 IMAGERY (AUGUST 24)
OF OAKLAND COUNTY (SCENE 1032-15521)

Lake	Area (Acres)	Max. Depth	Shore Length Miles	Lake** Number
*Orchard	788.0	110	57	344
*Cass	1280.0	123	115	331
*Pine	395.0	90	43	347
Wing	108.0		15	494
Walnut	232.0	101	32	381
*Wolverine	241.0		70	299
*Commerce	262.0	66	54	256
*Bass	37.0		10	277
*Reed	32.0	48	13	266
Hawk	13.0		5	303
Green	166.0		30	340
*Union	465.0	102	40	232
*Long	146.0	10	23	231
*Cooley	86.0	56	23	236
Pleasant	41.0		14	366
Lake Angelus	413.0	92	44	842
*Upper Straits Lake	323.0	96	55	359
*Lower Straits Lake	235.0	20	41	258
*Middle Straits Lake	171.0	55	41	263
Mud	6.2			349

*Bathymetry map available and in hand.
**Identifier for Bendix/Cranbrook Institute of Science Records.